Space Weather Technical Forecast

Issued on Thursday, 29 December 2022 at 01:31 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of Minor Geomagnetic Storms later day 1 into day 2 (29th/30th). Chance of M-class flares throughout. Chance or Slight Chance of Active electron fluence throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours with occasional C-class flares, the largest of which was C6.1 flare at 28/0330 UTC from AR3176 in the northeast. There are six numbered sunspot groups on the disc and one unnumbered region that developed in the southwest during the second half of the UTC day. The two largest regions on the disc; AR3169 (Fso/Beta) in the northeast and AR3176 (Esi/Beta) have shown little change or perhaps some decay through the period. The region that has been appearing round the southeast limb is still coming into view, but has been numbered AR3177 and initially classified as Dsi/Beta. All other regions on the Earth facing disc remain small and simple.
No earth directed CMES were observed in the available imagery during the period, despite some drawn out X-ray signatures.

Solar Wind / Geomagnetic Activity: Solar wind speeds, as measured by DSCOVR and ACE at L1 were elevated between 500 and 550 km/s for much of the period but dropped to slightly elevated levels from 28/2100UTC. The solar wind density was relatively stable at average or slightly above average levels (5-12 ppcc). The IMF has been weak around 5nT throughout. The north-south component, Bz, fluctuated weakly between +4/-5nT. The phi angle was mostly positive (away from the Sun). The solar wind parameters were indicative of a positive coronal hole fast wind, resulting in Quiet to Unsettled (Kp 1-3) geomagnetic activity.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at Background levels.
High energy electron flux as recorded at GOES16 (greater than 2MeV), was generally at moderate levels, but temporarily peaked into High levels, with a maximum of 1150 pfu at 28/1545 UTC. The 24-hour integrated electron fluence followed a slight rising trend, recording 5.69e7 integrated pfu at 29/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity carries a daily Chance of M-class activity, with the main contributions from AR3169, AR3176 and AR3177. AR3169 is expected to depart the Earth-facing side through the course of Day 2 (30th December), but this is likely to be counteracted by arrivals across the eastern limb.

Solar Wind / Geomagnetic Activity: Slightly elevated solar winds are expected to become elevated, or perhaps strong, later on day 1 into day 2 (29th/30th December) due to the arrival of a fast wind enhancement from CH59/+. This may also be coupled by a glancing blow from a CME that left the Sun on the 25th, although this is low confidence. On day 4 (1st January) solar winds should gradually ease as the coronal hole influence wanes.
Geomagnetic activity is expected to be largely Quiet to Unsettled at first, becoming Unsettled to Active later on day 1 into day 2 (29th and 30th December), with a chance of G1/Minor

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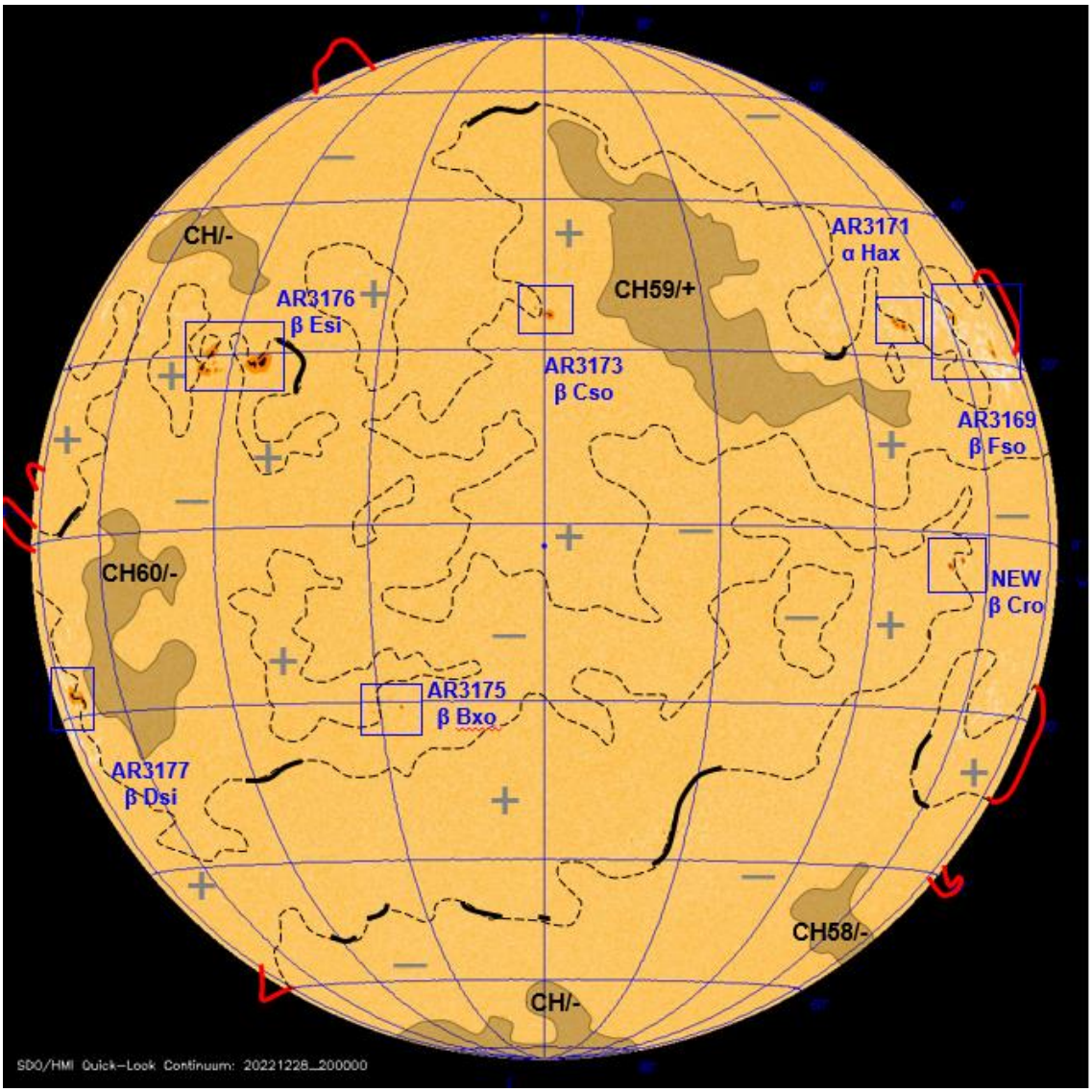
Geomagnetic Storm intervals, Geomagnetic activity and the risk of G1 should reduce through days 3 and 4 (31st December and 1st January).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels throughout, with a daily Slight Chance of reaching S1 levels.
High energy electron flux (greater than 2MeV) forecast is low confidence given the lack of utility of persistence methods (due to uncertainty in the arrival and effects of CMEs and significant coronal hole changes between rotations). Flux levels should persist close to the High threshold initially but should reduce should any CME effects materialise on the 29th December and due to the arrival of a HSS from CH59/+, before recovering through the second half of the period. There is a Chance of Active fluence on Days 1 & 2, perhaps recovering on Day 4 (1st January).

Figure 1. Solar Analysis Valid 28/2000.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME that left the Sun on the 25th December, should pass 1AU on 29th December, giving a glancing blow to Earth, although this is a low confidence aspect of the forecast, with the CME assessed as mainly south and ahead of the Sun-Earth line. No other CMEs feature in the forecast.
Solar wind speeds are currently slightly elevated. A high speed stream from CH59/+ is expected to arrive later on Day 1 (29th December), with Elevated, or potentially Strong, solar winds persisting through much of the period, before gradually declining on day 4 (1st January). This is based on empirical techniques, as CH59/+ is much changed from the previous rotation and thus recurrence is not providing good guidance. MOSWOC Enlil suggests a wind enhancement through Days 2, 3 & 4 (30th December -1st January). This is considered to be a little late given the shape and position of CH59/+ on the disc. STEREO A is currently around a day upwind of Earth in sampling the solar wind and is showing elevated to strong solar wind spends. This could potentially be due to CH59/+ which would also indicate an earlier arrival at Earth.
Geomagnetic activity is expected to be largely Quiet to Unsettled at first, becoming Unsettled to Active later on day 1 into day 2 (29th and 30th December), with a chance of G1/Minor Geomagnetic Storm intervals, due to the onset of CH59/+, perhaps coupled with the above CME. Geomagnetic activity and the risk of G1 should reduce through days 3 and 4 (31st December and 1st January), as influence from CH59/+ gradually wanes.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	40	30	10	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
25/1245	Partial	AR3169	NE quadrant	520 km/s	29th December	Low Confidence

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Radio Blackouts - X-Ray Flares:

There are currently six numbered sunspot groups on the visible disc and one unnumbered region.
Solar activity is expected to be Low or Moderate, with a daily Chance of M-class activity through the period. Two large regions in the northern disc: AR3169 and AR3176 statistically pose the greatest risk of M-Class flares, along with possible contributions from the the emerging spot near the southeast limb (AR3177). The main source of activity is likely to be AR3169, AR3176 and AR3177. AR3169 is expected to transit round the west limb to the far side on day 2 (30th). However, far-side soundings continue to suggest that there are sunspot regions lying close to the eastern limb that are likely to emerge through the period and thus the flare risk is maintained steady throughout despite the departure of AR3169.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	40	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) is currently at Background levels, and is expected to remain generally unchanged through the period.
Forecast probabilities remain at a daily Slight Chance of S1 due to the ongoing possibility of larger flares from AR3169 and AR3176. There have been no slight enhancements observed from any of the recent M-class flares, and many of the spots in the eastern hemisphere are not likely to become geoeffective through the period, with any protons enhancements unlikely to be significant.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	5	5	5	5
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) at GOES16 was suppressed at GEO during 27 December due to Geomagnetic activity, but has since recovered and remains at Moderate levels close to the High threshold. This recovery will perhaps be short-lived, with the possible glancing blow from the 25 December CME and the arrival of a HSS from CH59/+ by Day 2 (30th December). A recovery in flux values is likely from day 3 (31st December), but will be dependent on the strength of the HSS and its impact on the radiation belts.
Corresponding fluence levels may exceed the Active threshold during Day 1 (29th December), but otherwise are expected to remain at Background levels. Recharging and recovery of the radiation belts towards their usual position is expected towards the end of the period, at which point the chance of reaching or crossing the Active threshold increases. The changes in the shape and position of the upcoming coronal hole compared to the last rotation results in persistence forecasting and REFM providing little in the way of a useful steer.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	40	30	20	30
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

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